

Seasonal forecasting of precipitation over the Eastern Mediterranean

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Motivation

Seasonal forecasts months in advance could improve water-resource planning in Israel

- Winter precipitation over the Eastern Mediterranean is highly variable, strongly affecting water availability and drought risk.
- Key question: *How skillfully can seasonal forecast systems predict winter precipitation and large-scale circulation; what physical processes provide this predictability?*

Methods

9 C3S models compared with GPCP precipitation, ERA5 Z500, and NOAA SST over 1994–2016.

Sep → DJF

Jan → JFM

ACC

1. Precipitation forecast skill decreases with lead time

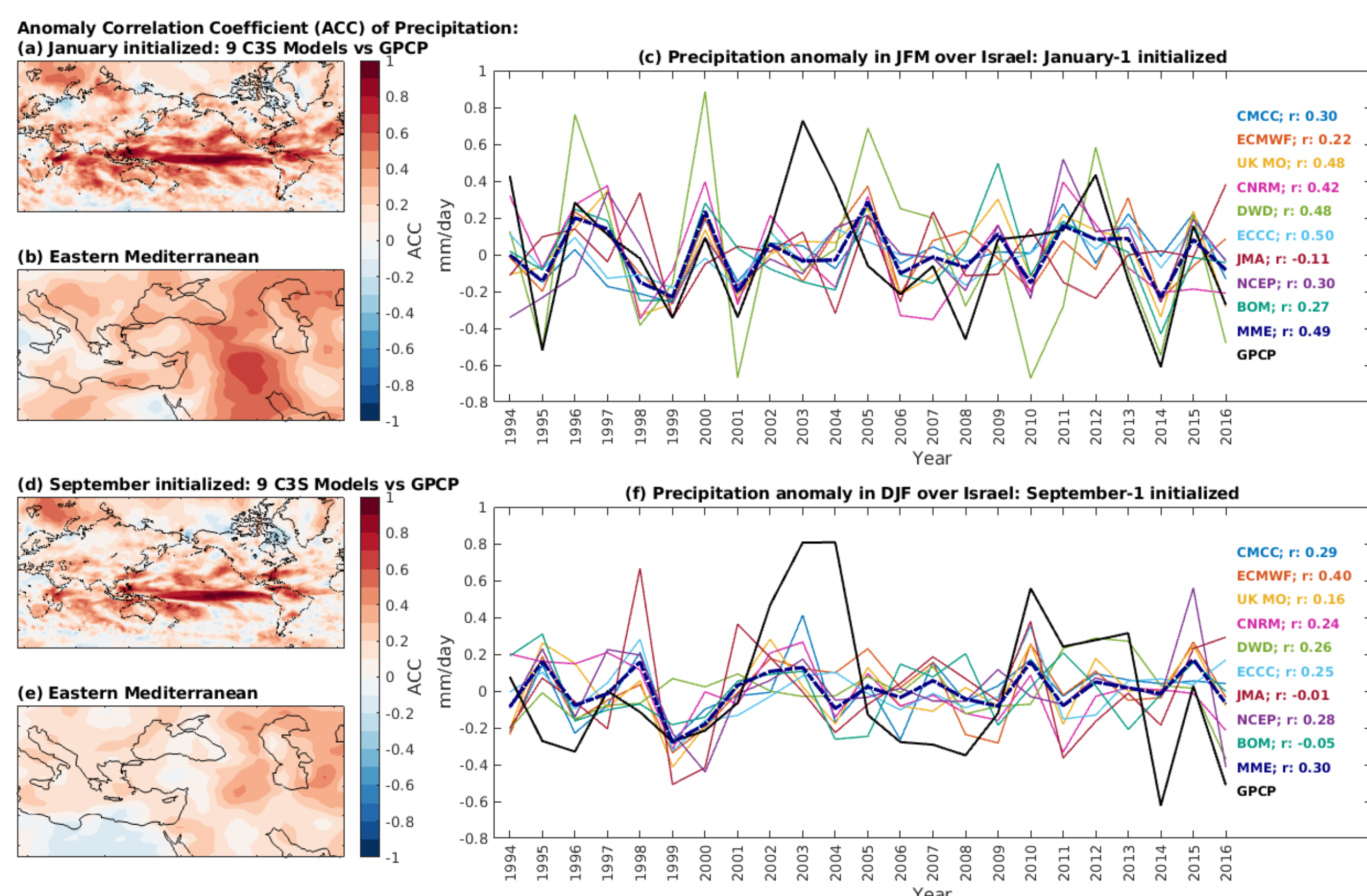


Fig. 1: Seasonal precipitation forecast skill for January- and September- initialized C3S hindcasts. Spatial anomaly correlation coefficient (ACC) between the nine-model and GPCP for January-initialized JFM (a–b) and September-initialized DJF (d–e), with corresponding precipitation-anomaly time series over Israel (c, f).

2. Large-scale circulation is more predictable than precipitation

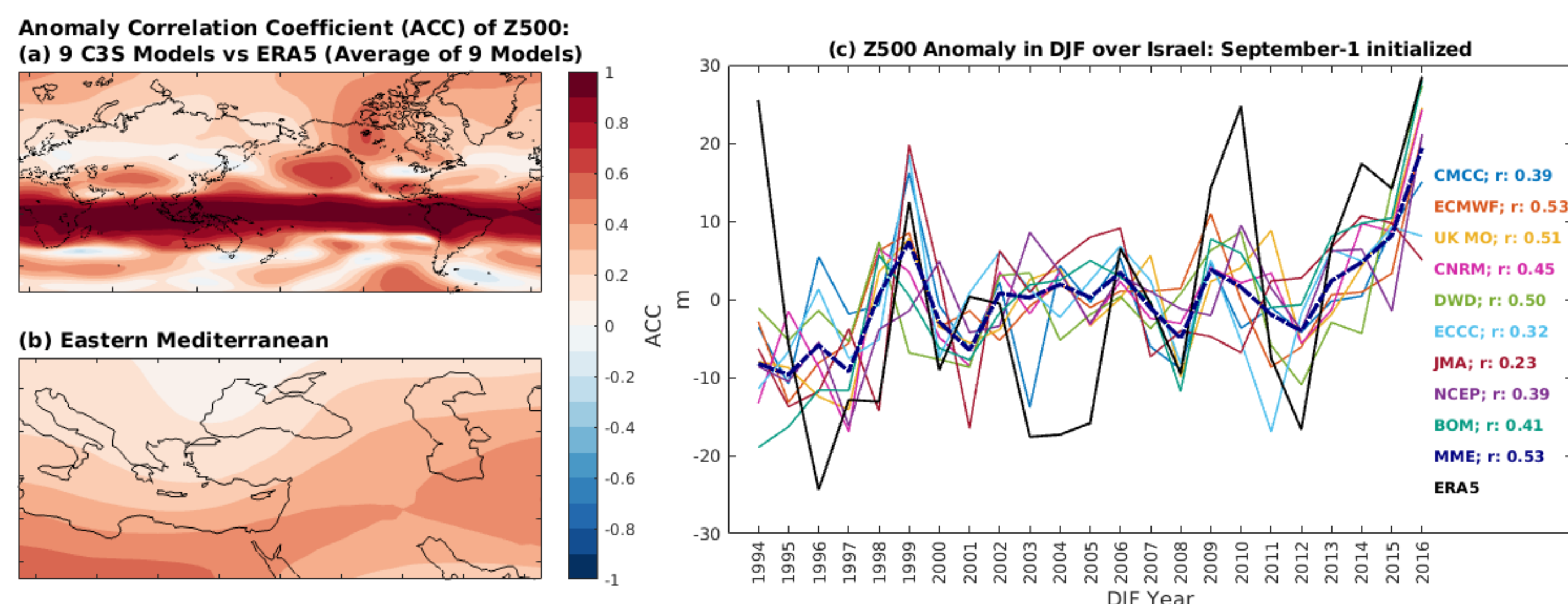


Fig. 2: September-initialized Z500 forecast skill. ACC between the nine-model and ERA5 for DJF 500-hPa geopotential height (a–b), with the corresponding Z500 anomaly time series over Israel (c).

3. Tropical Teleconnections to Eastern Mediterranean Z500

3a) Effect of Western Indian Ocean September SST on DJF Z500

3b) Effect of Nino 3 September SST on DJF Z500

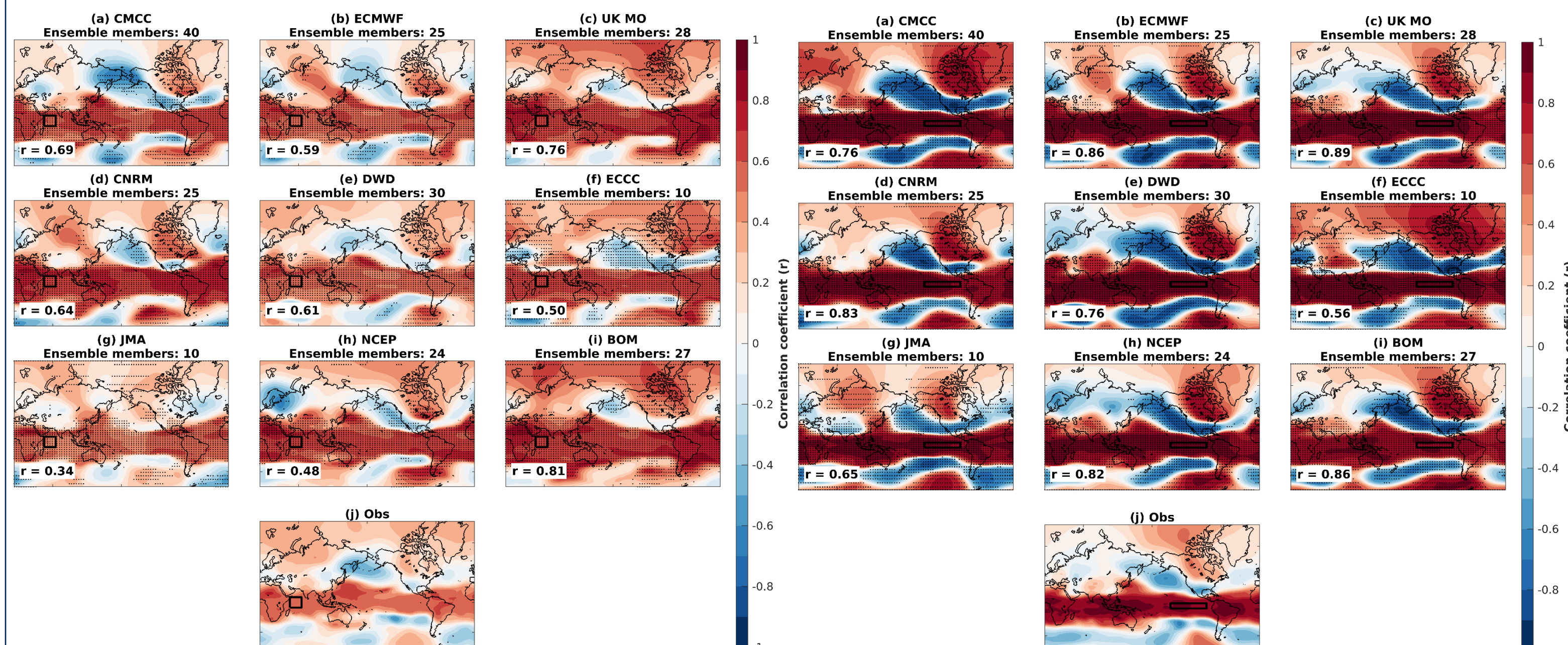


Fig. 3: Tropical SST teleconnections to DJF Z500. Relationship between September tropical SST variability and subsequent DJF Z500 across the 9 C3S models (a–i) and observations (j). (3a) Western Indian Ocean SST–DJF Z500 correlations. (3b) Nino3 SST–DJF Z500 correlations. Values of r show model–observation spatial pattern correlations.

4. More realistic teleconnections are linked to higher Z500 forecast skill

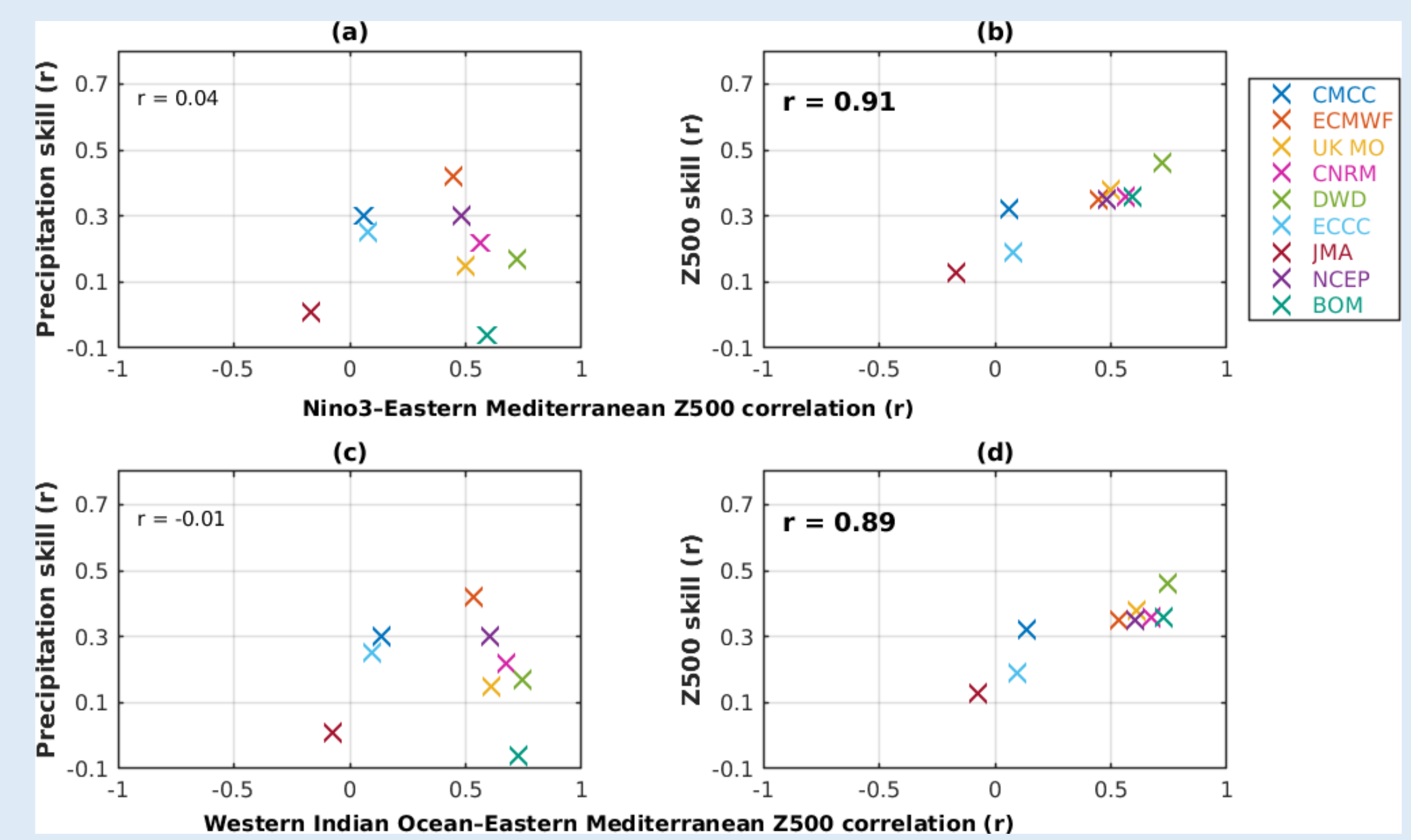


Fig. 4: Relationship between teleconnection fidelity and forecast skill across the nine C3S models. (a) Nino3–Eastern Mediterranean Z500 teleconnection versus precipitation skill, (b) versus Z500 skill, (c) Western Indian Ocean–Eastern Mediterranean Z500 teleconnection versus precipitation skill, and (d) versus Z500 skill.

5. Better Models, More Consistent Ensemble Teleconnections

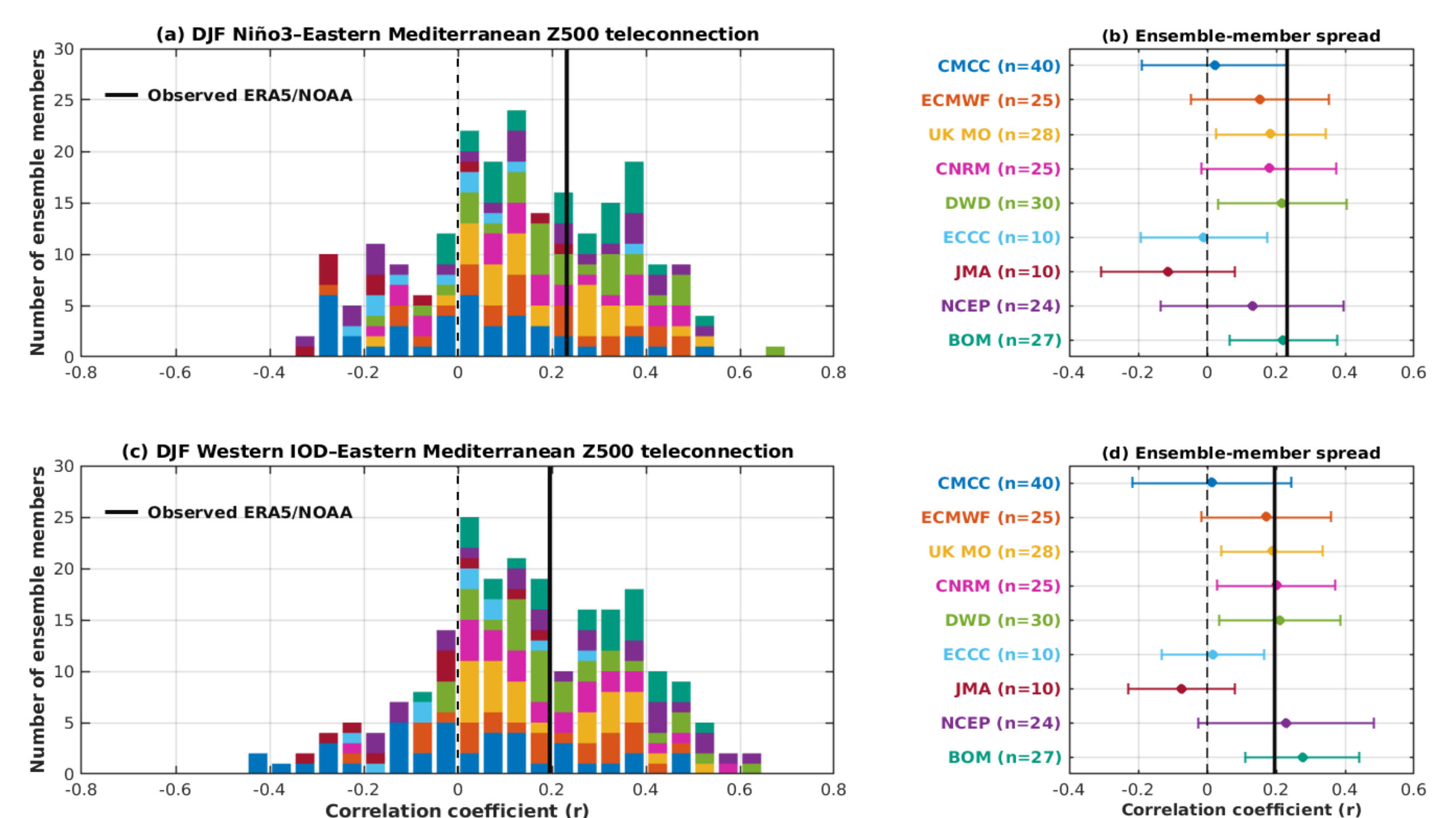


Fig. 5: Ensemble-member representation of tropical teleconnections. Distributions and model-wise ensemble spread for (a–b) Nino3 and (c–d) Western Indian Ocean teleconnections. The black vertical line marks the observed ERA5–NOAA correlation.

6. 2003 Forecast Bust : The Circulation Was Missed

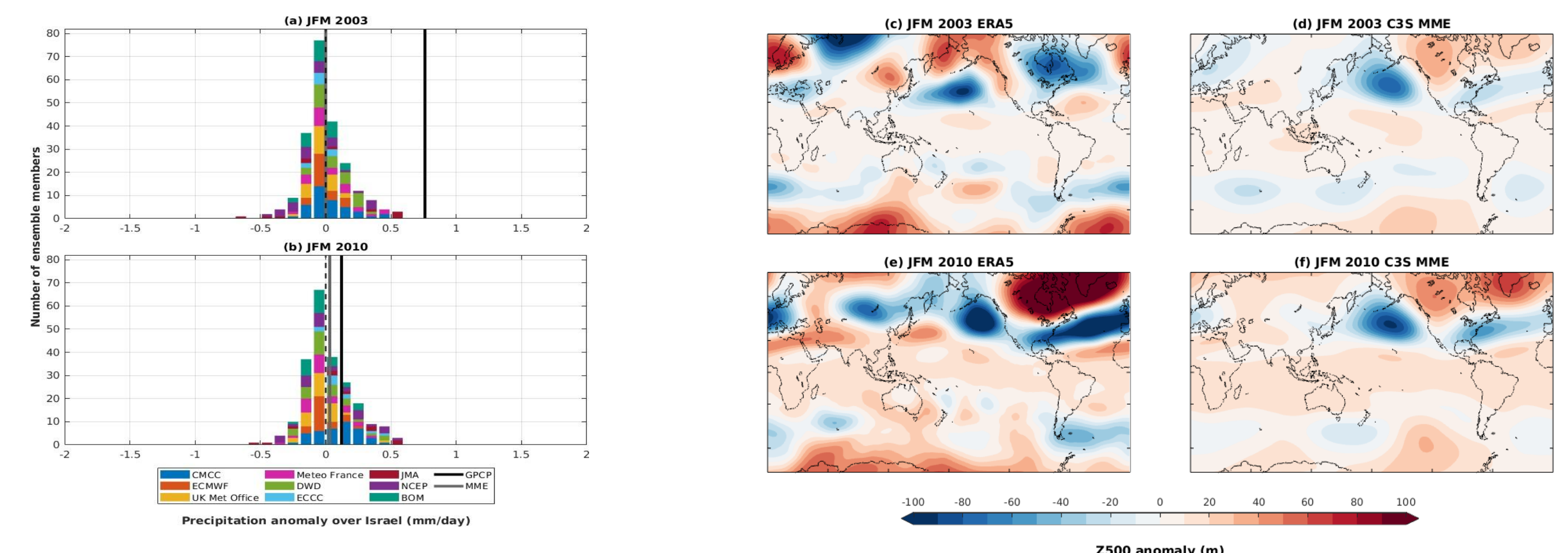


Fig. 6a–b: Ensemble-member precipitation forecasts for contrasting years. January-initialized JFM precipitation anomalies over Israel for (a) 2003, a forecast-bust year, and (b) 2010, a relatively skillful year. The black line marks GPCP.

Fig. 6c–f: Circulation anomalies during the forecast bust and skillful year. JFM Z500 anomalies for 2003 (c–d) and 2010 (e–f). ERA5 observations (c, e) and corresponding C3S multi-model ensemble-mean forecasts (d, f).

Conclusions

- January-initialized precipitation forecasts are more skillful than September-initialized forecasts over Israel (MME $r = 0.49$ vs 0.30).
- Large-scale circulation is more predictable than rainfall several months ahead, indicating that Z500 provides a more robust source of long-lead predictability for the Eastern Mediterranean.
- September Nino3 and Western Indian Ocean SST anomalies provide an early source of winter predictability, influencing Eastern Mediterranean circulation through tropically forced atmospheric wavetrains.
- More realistic teleconnections are associated with much higher Z500 forecast skill; Better-performing models also show more consistent ensemble-member teleconnections.
- Forecast failures can arise when the atmospheric pathway is wrong even when the tropical forcing is present. In 2003, the entire ensemble missed the wet event because the observed extratropical wavetrain and Eastern Mediterranean trough were not captured, whereas 2010 was represented much better.
- Improving the representation of tropical–extratropical teleconnections may be key to improving seasonal forecasts for the Eastern Mediterranean.

References

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- Hoell, A. et al. (2015). The forcing of monthly precipitation variability over Southwest Asia during the boreal cold season. Journal of Climate, 28, 7038–7056.